Reference Division

Armed Forces Medical Library

Notes to Accompany an Exhibit on The Early History of Spectacles

July - August
1956

Compiled by
Mrs. Justine Randers-Pehrson
Catalog Division

Washington, D.C.
June 1956

Early History of Spectacles

Spectacles are the composite invention of many of the most brilliant men in the history of science. Philosophers, monks, mathematicians, physicists, microscopists, astronomers, and chemists all played vital roles in developing this instrument which we today take so much for granted.

Magnifying and burning glasses were known to the ancients, but the use of the lens as a corrective instrument was unknown.

Undoubtedly a magnifying glass was used in pre-spectacles times for the deciphering the manuscripts. A convex lens of rock crystal or quartz would be pushed from word to word across the parchment.

No one knows who first mounted a lens that could be held near the anterior focus of the eye. Spectacles of some sort began to be used in Europe, perhaps first in Italy, not long before the middle of the 13th century, when Venetian glass manufacture began.

Francesco Redi (1626-1698) had in his library an old manuscript, written circa 1299, in which the author speaks of wearing "okiali" which had been "recently invented for the sake of old men whose eyesight had begun to fail." This is purported to be the earliest reference to spectacles.

Redi seems to have distorted deliberately another document, to the effect that the monk Alessandro della Spina of Pisa was the actual inventor of spectacles. Other historians interpret the document, which quotes a sermon of Giordano da Rivalto, circa 1305, to mean that Spina had seen spectacles made by someone else and had thereupon proceeded to manufacture others. Spina is sometimes referred to as the "rediscoverer" of spectacles.

The problem of identification of the inventor of spectacles was attacked by Domenico Manni, who dedicated his Degli ochiali da naso (1738) to his hero, Salvino degli Armati of Florence, a friend of Spina's. Armati was supposed to have invented spectacles in 1285, but there is little to substantiate the claim.

Armati's restored tomb in Florence bears the following inscription: "Here lies Salvino degli Armati of Florence, inventor of spectacles. May God pardon him his sins. 1317."

The oldest known pictorial representation of spectacles, a fresco painted by Tommaso Barisino of Modena in 1352, shows Cardinal Ugone da Provenza wearing "rivet" glasses. This form merely perched on the nose, or was held at the rivet with the thumb and forefinger.

The early spectacles were prized possessions of rich scholars and churchmen, and are mentioned frequently in wills and other documents. A letter circa 1415 from the monk Johannes Hildebrand in Östergötland to Bishop Knut Bosson Natt och Dag of Linköping says, "Holy Father, I beg you to return the spectacles I gave you, since they have been broken. I will not fail to send others in return."

The first book on spectacles was written by Cardinal Nicolaus Cusanus (1401-1464). De Beryllo, which contains the earliest record of mounted lenses

as eyeglasses, includes remarks on concave lenses, which must have been decidedly uncommon at the time the book was written. This book probably fixed "Brille" as the German word for glasses. Beryl was one of the original materials used for lenses, probably because of its property of cleavage into layers suitable for polishing.

The first modern-language book on spectacles was the Uso de los ojos, written by Daca de Valdez, a notary of the Spanish Inquisition, in 1623. This practical volume contains accurate information about ametropia and presbyopia, as well as the corrective properties of spectacles.

An interesting feature of the work is the system of designating the refractive power of glasses by measuring the apparent enlargement by convex lenses or reduction by concave lenses of a circle of known dimensions.

The AFML copy of this rare volume is one of the treasures of the literature of optics.

Spectacles were not immediately accepted by the medical profession. Bernard de Gordon (died circa 1308) according to his Lilium medica apparently preferred salves to spectacles. "Hoc collirium est tante virtutis quod decrepitum facent legere literas minutas sine oculo berillino."

Guy de Chauliac (1300-1370) the most famous surgeon of his time, wrote "If this collyrium does not help, one must have recourse to spectacles of glass or crystal."

Physicians in general persisted in their distrust of spectacles. Georg Bartisch (1535-1606) wrote "Aber es sey inm wie ihmwolle, so ist es nicht eine gute gewonheit, und ist viel besser und nutzlicher das man den Brillen nicht bedarff."

Spectacles caught the popular imagination. The fact that they were associated with scholars and with wisdom is reflected in works of art. Saints and patriarchs were anachronistically depicted wearing them.

Saint Jerome (331-420) is only occasionally shown with spectacles, in spite of the legend that he invented them. He was regarded as a patron saint by Venetian spectacle makers.

Guirlandaio's portrait shows spectacles at the side of the writing desk.

Since spectacles symbolized wisdom to the simple-minded, it was natural that charlatans should adopt them. The "Theriakhandler" almost invariably wore them.

Hawkers sold spectacles in the streets. The purchaser tried on various pairs and selected the one of his preference.

John Lydgate's London Lackpenny, circa 1400, contains a street cry,

"Master what will ye copen or buy?
Fyne felt hattes, or spectacles to rede?"

"Povert a spectacle is, as thinketh me,

Through which he may his verray frendes see."
"The Wife of Bath" in Chaucer's Canterbury Tales

Panurge "took four French ells of a coarse brown russet cloth, and therin apparreling himself as with a long, plain-seamed and single-stitched gown, left off the wearing of his breeches, and tied a pair of spectacles to his cap."
Rabelais

"I lost fair England's view
And bid mine eyes be packing with my heart,
And called them blind and dusky spectacles
For losing ken of Albion's wished coast."
Queen Margaret in Shakespeare's Henry VI part 2

"Spectacles are for Sight, and not for Shew,
Necessity doth Spectacles commend,
Was't not for need, there is but very few,
That would for wearing Spectacles contend."
Bunyan's Book for boys and girls, or Country rhymes for children.

Spectacles appear in the armorial bearings of noble families and of towns, on coins, in ecclesiastical sculpture, and in stained glass (circa 1500 from the Netherlands).

That spectacles were at one time all the rage in the more frivolous ranks of society is indicated by a letter by Madame de Mothe, dated 1679.

The invention of spectacles implies a combination of optical knowledge and technical skill which would have been impossible before the 13th century. Even then, as Sarton says, the invention was premature because some of the problems involved could not have been formulated. Neither the nature of light nor the function of the crystalline lens and retina were understood.

At the end of the 12th century, the first Latin translation of Ibn al-Haitham's Optics appeared, stirring the imagination of European scholars.

Witelo, the Polish physicist, (1220-1280) was the first European scientist of any stature to write on vision. His Optics, composed between 1270 and 1278, was derived in large part from Ibn al-Haitham's work, and constitutes an important link in the transmission of Arabic knowledge to Europe.

There is no reference to spectacles in this comprehensive study.

Though Witelo's work was almost entirely derivative, his fame was so enduring that Kepler, writing on optics in 1604, entitled his book "Ad Vitellionem paralipomena".

It has been conjectured that spectacles were invented by Roger Bacon (1214-1294). The principal evidence in Bacon's favor is contained in his Opus Majus, but the passage on the convex lens referes to the holding of it above letters to magnify them.

The lurid tale of his flight from England and his stealthy communication of

the art of spectacle-making to a go-between who carried the information to Italy is now known to be an elaborate hoax.

Bacon did actually experiment with burning glasses, and vaguely foresaw the wave theory of light.

It is interesting to observe that Bacon was largely neglected by scholars before the 16th century. His most important work was printed for the first time in 1733.

Some historians feel that Bacon alone had the requisite knowledge for the invention of spectacles. However, Robert Grosseteste, Bacon's teacher, was the first medieval writer to discuss the properties of mirrors and lenses systematically.

Grosseteste, who had one of the most scintillating minds of his age, held that the laws of optics were basic to the explanation of all natural phenomena.

Archbishop John de Peckham of Canterbury (circa 1240-1294) was another contemporary of Roger Bacon whose knowledge of optics was comprehensive. His pioneer volume on optics in English contains a summary of the theory of convex and concave lenses. The 1504 edition of his Perspectiva contains what is probably the oldest printed diagram of the eye.

A stumbling block was the lack of understanding of the way in which the eye forms an image. Witelo, Bacon, and Peckham, following Ibn al-Haitham, had recognized the function of the crystalline lens as a focusing organ, but all supposed it to be also photosensitive.

Francesco Maurolico of Messina (1494-1575) was the first to show correctly how the crystalline lens focused the rays onto the retina. As a result, he was able to explain far and near sightedness, and the use of corrective lenses. He was baffled, however, by the inverted retinal image.

Giambattista della Porta (circa 1535-1615) thought that the visual image was formed on the surface of the crystalline lens, and that the retina acted as a concave reflector.

He is considered to be one of the founders of modern optics because of his work with the camera obscura. He discussed convex and concave lenses in his De refractione, explaining the use of the concave in myopia.

Felix Platter (1536-1614) was first to recognize the function of the retina, and to describe the crystalline lens as solely a dioptric instrument.

Johannes Kepler (1571-1610) observed that the retina is essential to vision, forming a real inverted image. He took the preliminary steps in the formulation of the law of refraction when he showed, that the angle of refraction for small angles is proportional to the angle of incidence.

Kepler's work on the retina had been theoretical. Father Christopher Scheiner (1579-1650) made a practical demonstration by removing a portion of the opaque outer layers at the back of the eyeball and making the retinal image directly visible.

Scheiner also did pioneer work in deducing that the crystalline lens altered its refractive power when the eyes were turned from a distant point to a point nearby.

Willebrod Snell (1591-1626), professor of mechanics at Leyden, was the formulator of the sine-law of refraction. Snell's unpublished calculations are generally considered to have antedated those of Descartes.

Early artisans were incapable of producing flawless optical glass, accurately ground as we expect it to be today. Spectacle-makers selected pieces of glass which they considered suitable from lots intended for ornamental creations. Even as late as 1770, Deshais-Gendron complained of spectacles that "They are badly polished, which affects their transparency, there is never the same thickness in the two glasses, their material is usually thready, filled with bubbles and other imperfections..."

Glass-making is an ancient art which consists essentially of melting certain ingredients at a temperature high enough to produce a fluid mass which permits the escape of any bubbles forming in it.

Historians assume that the first spectacles were made of Muranese glass. Venice was ideally situated, having easy access to vast supplies of wood from Yugoslavia for the furnaces, with the sand of the Lido and Verona close by, and with a fine clay for crucibles available at Vicenza. Salt could be taken from the sea, and soda of finest quality could be brought in ships from Egypt.

In 1224 there were 29 persons listed in Venice as "friolari," and in the same century, codes of trade regulations were drawn up. In 1268 the glass workers became an incorporated body, and shortly afterwards the entire industry was transferred to the island of Murano, apparently as a safeguard against fire.

Georg Agricola in his De re metallica (1556) described in detail the processes of glass-making which he had observed in Italy. The furnace shown is three-chambered, being fired from below.

There was little change in the procedures of optical glass-making until the 18th century. John Dollond in the Philosophical Transactions of 1758 presented his "Account of some experiments concerning the different refrangibility of light," reporting his discovery of a means of making achromatic lenses by combining crown and flint glass.

Flint glass obtains its name from the fact that when lead glass was first made, flints were used as a source of the silica in its composition.

The expression "crown" appears to have been applied originally to the type of window glass made in the shape of discs, the center of which formed a bullion such as may still be seen in the windows of early colonial houses.

Joseph Fraunhofer (1787-1826) originally worked with Pierre Guinand who was the first to advocate the stirring of molten glass to overcome the lack of homogeneity. Fraunhofer, who was a brilliant self-taught mathematician, originated the specification of refraction and dispersion of glass in terms of certain lines of the spectrum discovered by him and subsequently named Fraunhofer lines.

He invented grinding and polishing machines, and methods of testing by means

of Newton's rings.

The process of grinding and polishing was for centuries carried on by hand. The discs of glass were brought to the proper form by being rubbed upon appropriately shaped "tools." Convex lenses were ground in a concave copper dish called a lanx, while concave lenses were shaped by rubbing the glass on a metal tool formed like a part of a sphere.

One grade of moist emery was usually used throughout the process, and final polishing was done with a cloth impregnated with putty powder or tripoli.

Various mechanical contrivances were devised for grinding and polishing. These machines were often the invention of leading scientists whose interest was lens making for microscopy or for telescopes.

Hevelius, the Danzig astronomer, invented a mechanical grinder.

Christopher Wren (1632-1723) who was an anatomist, microscopist, and astronomer as well as architect, contrived an "engin" for shaping hyperbolic lenses. He made a further contribution to the development of corrective spectacles by measuring and drawing the spheres of the humours of the eye.

His friend Robert Hooke (1635-1703) like Wren a man of extraordinarily diversified interests, as Curator of Experiments of the Royal Society tested and invented much apparatus for perfecting lenses. He also constructed an artificial eye for the study of optics. Hooke's Micrographia is a classic, containing the original formulation of the wave theory of light.

Christiaan Huygens (1629-1695) the celebrated Dutch astronomer and mathematician, is best known for his investigations on the wave theory of light.

His interest in optics led him to devise methods for grinding and polishing lenses which he described in his De vitris figurandis.

The illustration shows stages of making a "tool" for final polishing invented by Huygens and perfected by Molyneux. This tool was a thick plate of cast brass which was ground with emery and two flat polishing stones. It was polished by coating one stone with pitch and feeding emery between the metal and pitch under considerable pressure. The glass blank was placed in a concave depression to correspond to the finished lens.

Most of the early works on lens-making are addressed by scientists to others with similar interests. Chérubin d'Orléans wrote his Dioptrique oculaire (1671) with the apprentice in mind. This "how to" book contains the first description of polishing machinery.

Some of the most illustrious makers of microscopes produced spectacle lenses and sold them, as indicated by their trade cards. Edward Scarlett's card shows his invention, ear pieces as part of the spectacle frame. For 400 years the problem of attaching spectacles had remained unsolved.

With the basic problems of optics and technology solved, the correction of specific difficulties of vision became possible.

In the Bakerian lecture for 1801, Thomas Young presented the first description of astigmatism, analyzing his own defective vision. He attributed the condition to an obliquity of the crystalline lens in relation to the visual axis.

Young did not realize the importance of his discovery. The term "astigmatism" was not suggested by him, but later by William Whewell, Master of Trinity College.

Astigmatism is probably the most common of ocular defects, being present in almost all eyes to some extent. Rays of light are not brought to sharp points on the retina but form short lines (our stars are not seen as dots: we seem to see light radiating from them).

Sir George Biddle Airy, Astronomer Royal, discovered astigmatism in his left eye about 1825. He calculated the focal powers needed for correction and had Fuller of Ipswich grind a sphero-cylindrical lens for him. This was the first time that a cylindrical lens was used in correction.

Airy wrote with satisfaction, "I have found that the eye which I once feared would become quite useless can now be used in almost every respect as well as the other."

Isaac Hays, surgeon at Wills Eye Hospital, Philadelphia, reported the fifth case of astigmatism in the entire world in 1834.

The spectacles prescribed by Hays were ground by the McAllisters in Philadelphia, one of the earliest optical establishments in the country. The McAllisters were first to grind cylindrical lenses in the United States.

Benjamin Franklin is generally credited with the invention of bifocal lenses. The Franklin type was made by halving lenses of differing powers and cementing the segments together with a straight line across the middle.

Franklin's bifocals were probably made by Peter Dollond of London.

Thomas Jefferson had similar glasses made to his specifications by the McAllisters of Philadelphia.

The form of lenses engaged the attention of the physicist, William Hyde Wollaston (1766-1828). He experimented with meniscus lenses (their curve had suggested the "moon" designation) and in 1804 published an article in the Philosophical Magazine "On an improvement in the Form of Spectacle Glasses."

Wollaston commented that while the crossed lens of Huygens gave minimum spherical aberration for direct axial pencils and could therefore be used for microscope objectives, it gave mediocre results when used as a spectacle lens.

"The more nearly any spectacle glass can be made to surround the eye... the more nearly will every part of it be at right angles to the line of sight... lenses should be more convex on their exterior surface, and concave within."

The sole manufacture and sale under patent was given to Peter Dollond.

In steel frames, the periscopic spectacles cost 10s 6d a pair, compared to the usual 3s 6d for similar frames with flat lenses.

When Dollond's patent ran out in 1818, competition set in. Periscopic lenses were then manufactured on the continent, in Germany by Duncker.

Pastor Johann Heinrich Duncker (1767-1843) is noteworthy as the founder of the Rathenower Optische Industrieanstalt (1801) in which disabled soldiers, as well as orphans of soldiers, were employed. In the interests of this rehabilitation project, Duncker devised and patented a lens-grinding apparatus.

Prismatic lenses are usually considered to be the invention of Donders, but the principle had been set down in 1792 by the American born physician, William Charles Wells (1757-1817) of Charleston, South Carolina. Wells, the son of a Tory Scotsman, moved to Britain at the time of the American Revolution.

In his "Essay upon single vision with two eyes," he says, "If flat-sided prisms were fixed in spectacle frames with their refracting angles towards each other, they would assist the long-sighted somewhat, without producing the evil which is said to arise from the convexity of glasses, and spectacles of this kind with more propriety than any others be called preservers."

A few remarks on the gilds: It is possible that the first spectacles industry outside of Italy was in the Netherlands. One of the Merry Pranks of Till Eulenspiegel says that he told the Bishop of Trier, "Gnädige Herr, ich bin ein Brillenmacher und komme aus Brabant." (Gracious Sir, I am a spectacle maker and come from Brabant.) Eulenspiegel died in 1350, and the pranks appeared in 1483.

The year 1535 is considered to be the birth date of the German spectacles industry. In that year the regulations of the Nürnberg spectacle makers' gild were formulated.

Up to 1500, twelve spectacle makers in Nürnberg are known by name. The first ones were independent, but in 1530 they had banded together and adopted an emblem.

The ordnance of the Regensburg spectacle makers is of a somewhat later date than its Nürnberg counterpart. At the peak period of the Regensburg trade, requirements for the mastership were extremely severe. Ten masterpieces were required, as well as the making of all kinds of implements and iron tools for manufacturing spectacles. One month was the working period stipulated for the making of the masterpieces.

In 1465 there was a procession through the streets of Paris of 80,000 merchants and artisans, passing in review before Louis XI. The spectacle makers marched under 49 banners, together with the shopkeepers and carpet makers. The device shown dates from 1575 or later: at that time the spectacle makers joined the mirror makers in one gild.

In 1628 eleven London opticians and their legal advisers met to consider putting their craft on an official basis. King Charles I granted a charter in 1629. This document is the only one of the gild's records that survived the Great Fire.

Apparently the company was a sizeable one. It is known that at the start they had a master, two wardens, eight assistants, and a clerk.

Although ancient figurines give evidence that eye protectors were used in the Orient in the Stone Age, the lenses described in legends of Cho-Tso, the patron of opticians, and in the annals of the T'ang Dynasty (618-906) probably were not ground for optical purposes. Apparently they were burning glasses known as "fire pearls" which were imported into China either from Kashmir or from the vicinity of Java.

In the Tung tien ch'ing lu, written by Chao Hsi-kung of the Sung Dynasty (960-1278) there is said to be a character "ai-tai" which means spectacles. The meaning given for the characters is, "Old men were unable to distinguish minute writing. Hence they covered this over their eyes and writing became clear."

Certain etymologists feel that "ai-tai" was an expression which originated beyond the borders of Western China.

Although glass manufacture was introduced into China before the Anterior Han Dynasty of the Five Dynasties period (907-960) it is unlikely that there is any substance to the unverified report that Marco Polo found spectacle wearers in China.

There is general agreement among historians that spectacles were not a Chinese invention, but were introduced by early missionaries, possibly by the Spanish Jesuits in 1583.

There is a striking similarity between the thread attachments of the Spanish models of that period and those of Chinese models drawn in the 18th century.

Early Chinese glasses were large and round. They were used not only for failing sight but also as a sign of dignity, and sometimes as a remedy for diseased eyes.

They were generally plano-convex, made of tinted rock crystal or topaz. The character shown means "tea stone."

Frames were of horn, tortoiseshell, or paper maché, with brass or white alloy bridges.

Convex spectacles were numbered according to age.

Powers for concave spectacles were named after animals, ranging from pig (the weakest) through intermediate strengths dog, cock, monkey, sheep, snake, dragon, rabbit, tiger, and ox up to the strongest, i.e., rat.

The rivet glasses of the Orient closely resemble their European predecessors.

Some historians believe that the Chinese invented the hinged frame. Others attribute this invention to the London optician James Ayscough (1719-1762). There is a remote possibility that Ayscough might have seen and copied Chinese models, but in all likelihood the Ayscough models made their way to China and were copied there.

Spectacles were an importation in Japan, since the Japanese had no independent study of optics. A foreign missionary is reported to have given a pair to Yoshitaka Ouchi, circa 1532.

There are spectacles preserved in the Buddhist temple in Kunoyama in Shizuoka which are supposed to have been used by Ieyasu Tokugawa (1542-1616). These are the Spanish thread type.

The Kaikoku shidan (Maritime histories) states that Gohei Hamada of Nagasaki went to countries south of Japan in 1632 and learned how to make spectacles. He returned to Japan and taught the art to Fujiyoshi Ikushima.

The nose support is typical of Japanese spectacle frames. This post attached to the bridge was designed to keep the lenses from contact with the eyes of persons with low nose bridges.

Mr. Milton A. Murayama's translation of Oriental material is acknowledged with thanks.